



TABLE 3

FT MICROWAVE SPECTROMETER SENSITIVITY TESTS		
Compound	Formula	mds ¹ (ppb)
Acrolein	H ₂ C=CHCHO	0.88
Carbonyl Sulfide	OCS	1
Sulfur Dioxide	SO ₂	4
Propionaldehyde	CH ₃ CH ₂ CHO	100
Methyl t-Butyl ether	CH ₃ OC(CH ₃) ₃	65
Ethyl t-Butyl ether	CH ₃ CH ₂ OC(CH ₃) ₃	120
Vinyl Chloride	CH ₂ =CHCl	0.45
Ethyl Chloride	CH ₃ CH ₂ Cl	2
Vinyl Bromide	CH ₂ =CHBr	1
Ethylene Oxide		11
Toluene	CH ₃ -C ₆ H ₅	130
Vinyl cyanide	CH ₂ =CH ₂ CN	0.28
Acetaldehyde	CH ₃ CHO	1
Propylene Oxide		11
para-Tolualdehyde	CH ₃ C ₆ H ₄ CHO	150
Methanol	CH ₃ OH	1000
Benzaldehyde	C ₆ H ₅ CHO	26
Propene	CH ₃ CH=CH ₂	250

¹ Minimum detectable signal for the following set of parameters: Neon carrier gas; average of 100 gas pulses taken at a 2 Hz repetition rate (50 sec total integration time).

FIG. 8 shows an embodiment of the present invention having two fixed-tuned Fabry-Perot cavities in a single vacuum chamber. Microwave input **824** and circulator **828** direct irradiating microwaves into chamber **822** and cavity **834** through mirror **814** while the gas input nozzle **818** is located at mirror **816**. Microwave input **826** and circulator **830** direct irradiating microwaves into chamber **822** and cavity **836** through mirror **810** while the gas input nozzle **820** is located at mirror **812**. The data acquisition system **832** is attached to circulators **828** and **830** to monitor and detect the chambered gases and microwaves.

The software system of the present invention has been developed for a **486** personal computer which allows instrument control via a standard mouse using point-and-click techniques. The software employs a Graphical User Interface and is very user-friendly.

OPERATION

Referring again to FIG. 2, the instrument operates by first pulsing a gas sample into Fabry-Perot microwave cavity **215** with pulsed valve **218**, then "polarizing" the molecules in the gas sample with a microwave pulse from a broad-banded, (2–26.5 GHz) single-pole double-throw microwave switch **222**. Switch **222** feeds a broadbanded, single-sideband modulator **230** which increases the microwave frequency entering the cavity by 30 MHz. The RF switch **224** is pulsed in synchronization with switch **222** to achieve an on/off ratio of 100 dB. This assures that no microwave leakage from the modulator **230** into cavity **215** is present when microwave switch **226** is opened to begin the detection sequence. Switches **222**, **224** and **226** also eliminate the use of microwave circulators and isolators which many previous instruments employed. In addition, they allow the instrument to operate over four microwave bands (4–8 GHz, 8–12.4 GHz, 12.4–18.6 GHz, and 18.6–26.5 GHz) without switching microwave hardware components.

Once the microwave cavity is properly tuned to a microwave frequency which corresponds to a rotational transition frequency of a chemical species in the molecular beam, the Fourier components of the microwave pulse pump the rotational transition. Following the microwave pulse the molecular emission signal emanating from the cavity is first amplified with a broad-banded, low-noise microwave amplifier **220** (35 dB gain) which can optionally be cryogenically cooled to further improve the signal-to-noise ratio of the instrument. The amplified signal is then fed into a broad-banded, image-rejection microwave mixer **228** where it is heterodyned with the original output of the microwave synthesizer **232**. This image-rejection mixer **228** effectively eliminates noise originating in the opposite sideband thus increasing the signal-to-noise of the instrument by a factor of two. This mixer produces a 30 MHz IF frequency which is further amplified (40 dB) and filtered with a narrow-band 30 MHz filter **234** (1.8 MHz passband). This signal is then digitized in the time domain at 8 MHz (from generator **238**) using a 20 MHz digitizer **236**. The entire sequence can be run at 10 Hz so averaging is easily done by adding the individual digitized samples.

Microwave synthesizer **232** provides a 10 MHz reference **242**, which is fed to pulse controller **240** and to 3× multiplier **244** which then provides a 30 MHz signal to switch **224**.

The software package which is used to automate the instrument operates in a Windows-type environment using a graphical user interface (GUI). All components of the instrument are automatically controlled from the computer keyboard and a standard computer mouse. The instrument operates using a standard 80486 processor based personal computer. The software permits automatic tuning of the microwave cavity simply by typing in the desired microwave frequency. The instrument is capable of unattended automated frequency searches. Other options permit automated searches and detection for pre-selected chemical compounds in an unknown sample. Concentration variations as a function of time can also be followed automatically when monitoring a chemical process stream.

This instrument can be used for trace-gas analysis in a variety of analytical chemistry areas, providing real-time detection limits for trace-gas species in the parts-per-billion range.

What is claimed is:

1. A Fabry-Perot cavity Fourier transform microwave spectrometer comprising:

- a vacuum chamber;
- a first pair of mirrors positioned within said vacuum chamber, forming a Fabry-Perot cavity, each mirror of said first pair of mirrors having a surface with a surface finish of less than or equal to 0.25 microns rms.
2. A microwave spectrometer as in claim 1, wherein said surface of each mirror of said first pair of mirrors is coated with nickel.
3. A microwave spectrometer as in claim 2, wherein said surface of each mirror of said first pair of mirrors is further coated with either gold or silver.
4. A microwave spectrometer as in claim 1, wherein each mirror of said first pair of mirrors has an overall sphericity across its surface of less than or equal to 4 microns rms.
5. A microwave spectrometer as in claim 1, wherein one mirror of said first pair of mirrors forms one end of said vacuum chamber.
6. A microwave spectrometer as in claim 5, further comprising a receiving antenna located in said one mirror of